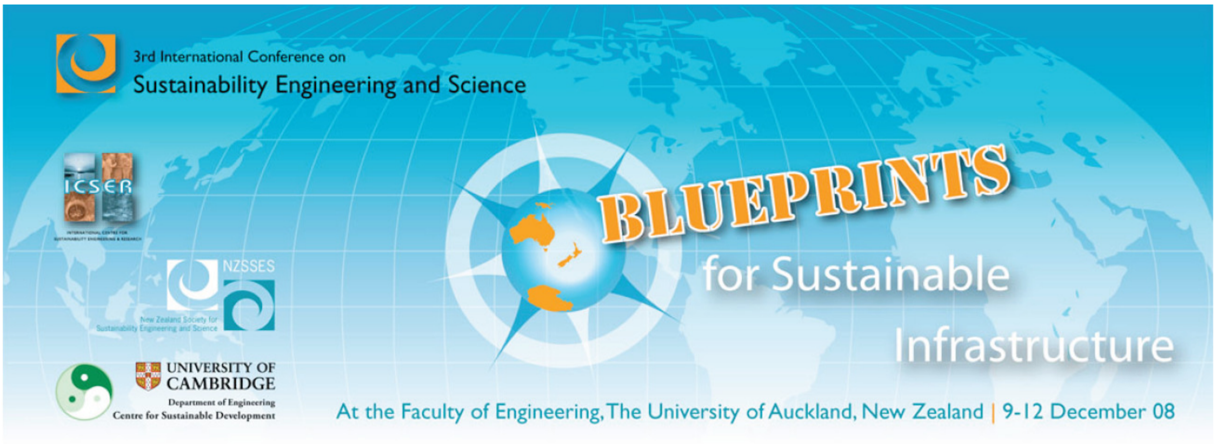

AUTHORS: **Dr. Susan Krumdieck**, Associate Professor (MRSNZ), **Dr. Andre Dantas**

Title of Paper: **The Visioning Project: Part of the Transition Engineering Process**

Advanced Energy and Material Systems Lab, Department of Mechanical Engineering, University of Canterbury
Private Bag 4800, Christchurch, New Zealand
Phone: (+64) (3) 364-2596 email : susan.krumdieck@canterbury.ac.nz Website : www.aemslab.org.nz

Abstract

The availability of transport options and energy sources is a strong determinant in the development of land use patterns. The current transport infrastructure and vehicle technology in developed countries has emerged during conditions of low-cost and abundant fossil fuel. It is not possible to simply substitute renewable fuels from any combination of resources in a way that reduces fossil fuel consumption while requiring no changes in land use, infrastructure and vehicle technology. However, many research scenarios focus on fuel substitution rather than transitional change of urban form and adaptation of public expectations. The paper presents a conceptual framework for the coherent integration of development projects involved in the new field of Transition Engineering. The research results focus on one of these projects, the visioning project. The research objective for the visioning project was to gain an understanding of the nature and magnitude of the systemic infrastructure changes that would be required to provide a modern quality of life using only renewable energy resources. A method was developed to generate feasible-sustainability concepts. The method first quantified the renewable energy resources available for transport in a New Zealand town, including biofuel, human power, and renewable electricity. Then transport system design concepts were generated using basic energy flow balance modelling for each major transport activity, e.g. personal mobility, access to markets and services, goods movements. The feasible-sustainability concept involved adaptive changes to the pre-transition urban form and infrastructure. The resulting urban form was recognisable yet radically different from the pre-transition neighbourhood. This feasible-sustainability transport system concept, based on a realistic use of renewable energy could fill a gap in the shared cultural vision that people in developed countries have about the long-range future, and should inform strategic investments in the near term.

Key words: Feasible Sustainability, Transition Engineering, Renewable Energy Transportation

Introduction

Renewable energy transport is often concieved by attempting to fit alternative technologies, such as electric cars, or biofuels into the current system that is inherently unsustainable due to profligate consumption of oil and sprawling land use patterns. For example, electric vehicles are currently being considered as an answer for sustainable transport, but there are some difficult infrastructure considerations such as the electricity demands of a large fleet of vehicles, or the fact that over 23% of New Zealand's electricity is generated from depleting gas resources and at least 10% from coal (MED 2007). Even if the current national strategy of achieving 90% renewable electricity were realised, is unlimited mobility on ever growing numbers of paved roads into ever expanding urban areas going to be sustainable? Is substitution of personal and freight transport with currently un-available electric vehicles even feasible? In what time frame could this plan be realised, at what cost? Expectations have been raised through the media of low carbon, renewable liquid fuels becoming available from biomass resources to substitute for fossil fuel, allowing us to maintain current mobility using our existing stock of vehicles. However, numerous studies have raised questions about the amount of liquid transport fuel people can expect to extract from already stressed agricultural land, and whether processing can actually be done in ways that reduce overall greenhouse gas emissions and produce more energy than invested (Pimentel 2005). Hydrogen is still being put forward in the media and funded by government research as a possible "green" technology, though researchers have provided evidence that a "hydrogen economy" is a false concept (Hammerschlag and Mazza 2005) (Bossel et al., 2003) (Keith and Farrell 2003).

Why does the media and government lurch from one "answer" for sustainable transport to another? Why do all of these answers look like our current private-car, unlimited-mobility infrastructure but with "green power" alternatives substituted for fossil fuel? We propose that lack of a clear cultural vision of feasible sustainability means that non-feasible technology substitutions can seem like solutions. Pursuing non-feasible alternatives in fact delays the work on feasible system adaptations.

The objective of the research project reported in this paper was to address this problem of public distraction and low-return research investment on non-feasible alternatives by generating a vision of feasible sustainability. The first section of this paper discusses the importance of vision in either society's progress, continuity, or collapse. The second section presents a conceptual framework that helps to rationalise the current disparate aspects of sustainability science and engineering. This section clearly shows the role of transitional visioning relative to historical study, stock-taking, scenario development, policy development, evolutionary economics and technology change. The final section describes the feasible sustainability visioning project that was carried out in 2003 and is now known as *The Silke Project*.

Without Vision the People Perish

Five years ago, I started conducting informal surveys of audiences at public seminars and workshops. The survey asked the following questions:

1. Name the first book or movie that pops into your head when you think of what the world will be like in three generations.
2. Is this vision of the future really possible?

The first set of results set off alarm bells. The answers have been consistent to the present day:

1. 80% *Mad Max* 20% *Star Trek*
2. Yes No

This is a problem. It is a problem because societies often make choices that achieve their shared cultural vision. If our shared cultural vision of the future is that civility and sanity will collapse, because the world goes to war, because oil runs out… then we may actually achieve what we envision. Jared Diamond in his book, *Collapse*, (2005) makes the interesting case that historically, collapsed societies have actually made choices that led to collapse. These choices are about continuing, or *not stopping*, unsustainable practices. In particular, an unsustainable relationship with environmental support systems results in changes in the society that, in retrospect, we would call collapse.

Let's do a thought experiment. If you asked the question, "what will the world look like in three generations?" to a group of people on any continent at any point in time prior to the fossil fuel age, the prevalent answer would be "it will look like now". People have always needed to know what the future was going to look like, but for most of our collective history that future vision has been supplied by our current reality. Societies have always trained and educated their children to replicate themselves, to carry on their way of life. Sustainability has long been defined along these lines – a society that can continue the way they do things for many generations.

The Advanced Energy and Material Systems Lab (AEMS Lab) at University of Canterbury, College of Engineering, has been involved in several sustainable energy research projects for remote locations and small islands (Hamm and Krumdieck 2005). We have asked people in these communities about their vision of the future. Although the energy services provided by Diesel generators, gas cookers and motor boats are appreciated, there is a sense that looking to their traditional way of life is an option for the future. This looking for vision in the past may be reflected in some of the "eco-village" or "perma-village" movements that have developed since the oil shocks and early sustainability-focused literature in the 1970's. Recently, the AEMSLab has become actively involved with "transition town" groups, providing a range of input and technical modelling that we have come to refer to as *Transitioneering*. However, as I continue to ask my informal survey question at transition town seminars, I haven't yet had anyone respond with *The Village,* a movie about a group of people who escape the social decay of New York city by re-creating life in the 18th Century countryside. Maybe it wasn't such a popular movie *as Mad Max*.

The fact that my fellow citizens, off the top of their heads, know that our society is unsustainable, and think that the consequence of that unsustainability is collapse, worries me a bit. I don't really want to go there with them, and I certainly don't think there is anything that we are doing now that is so important that it's worth risking my great-grandchildren's wellbeing. The obvious thing to do is an engineering research project to develop a feasible sustainability model of a renewable energy version of us. This would provide a shared cultural vision of life without oil as a possibility rather than as the end of the world.

In 2003 a group of researchers at the AEMSLab undertook a project to do the concept generation and feasibility design for a renewable energy-only transportation infrastructure and technology for a typical city in New Zealand. The research group included a sabbatical visitor and expert in human powered vehicles, Professor Eric Wang from University of Nevada at Reno. The group members and their specialities are listed below.

- Dr. Susan Krumdieck, Energy Systems Engineering, Sustainability
- Dr. Andre Dantas, Transportation Engineering, Freight Movement and Urban Form
- Prof. Eric Wang, Mechanical Engineering, Human Power Vehicles, Design
- Tony Burton, PhD Student, Energy System Engineering Consultant, Solar PV Design
- Silke Liettermann, Engineering Intern Student, Konstanz Germany
- Simon Minges, Engineering Intern Student, Konstanz Germany
- Andreas Hamm, PhD Student, Mechanical Engineering, Renewable Energy Systems

The rather standard methods of engineering concept development and feasibility design were used. Weekly free play and brainstorming meetings by the group as a whole were carried out over a period of about 6 months. Each meeting was followed by a week of technical and literature research, modelling and calculations, and the on-going construction of a physical scale-model of the renewable energy transport urban form (e.g. land use, production and market facilities, and transport networks). At the beginning of each meeting the research and modelling findings set out during the previous week would be discussed and incorporated and then the brainstorming would continue. The hardest part of the project was to maintain the perspective of the hypothetical people in the renewable transport urban form, which we came to call *Silke Village.* We had to continuously help each other eliminate our pre-existing assumptions if they were in-fact based on our experience or expectations from using fossil fuel. A tour of the *Silke Village* - a feasible sustainability design for a renewable energy transport infrastructure and urban form - will be launched shortly. But first, let's have a brief discussion about the systems view of change.

The Whole Picture

The king was having a hard time with his advisors. The country was in a difficult situation, and he needed all the help he could get to make important decisions. His advisors were all wise and learned men, but they continuously argued with each other and disagreed at every turn. Finally, the king, who was a wise man himself, told his six advisors that the young servant girl who kept the water jug filled could see things more clearly than they could. They were shocked and argued some more. How could a mere servant girl know more than the architect for the city's aqueduct, the head economist for the king's treasury, the commander of the army, the ambassador and trade negotiator, the master of the historical records, and the chief natural resource and agriculture adviser?

The king had the advisors blind-folded and taken to a room. He told them all they had to do was to tell him what was in the room with them, and see if they could provide a better answer than the servant girl. It is obviously a rope, long and frayed. It is obviously a tree, straight and tall. It is obviously a rock, smooth and hard. It is obviously a wall, solid and smooth. It is obviously a canvas tent, flexible and pliable. It is obviously a snake, and a large one at that.

The king shouted for silence over the arguing wise men. He asked the young girl, who had not been blind- folded, if she could tell the advisers what was in the room with them. She softly replied, "Master, anyone who looks can tell that it is an elephant."

The advisors complained even more loudly that the test was un-fair as they were blindfolded, and so couldn't see what the other experts were talking about. The king replied, "If you couldn't see, then why didn't you take the blindfolds off?"

There are a lot of smart people, with a range of expertise working on sustainability. The role of policy is normally to regulate or set the rules for what is already in play. It is clear to this author that elected leaders, regardless of their good intentions, are not going to be the force for change to sustainability. They usually want to make good decisions. None of them want our society to collapse. Every year, it seems that society progresses less toward sustainability than toward *Mad Max*.

Figure 1 shows "the whole picture" of the progress of moving a society toward a sustainable position from an unsustainable, yet profitable and even comfortable position. This framework will look familiar to engineers, as it resembles the product development process. It also has common elements with business planning and management. Let's look at each of the seven projects briefly, and see if, by putting the individual areas together, we get a new understanding of the whole picture.

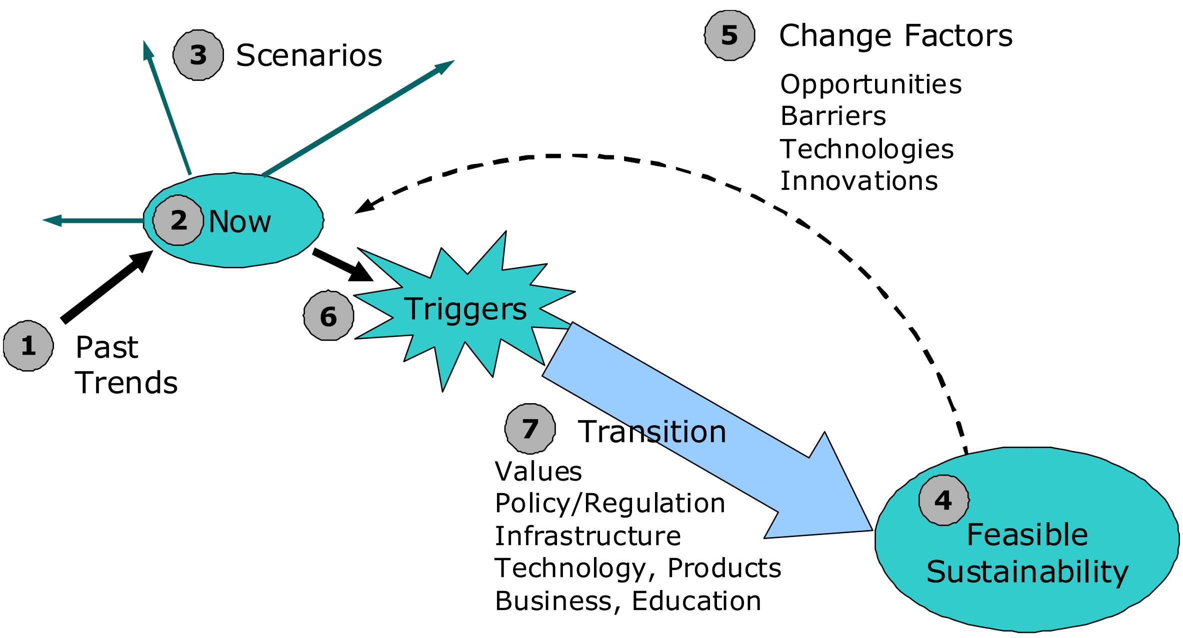

Figure 1. Seven distinct project areas for research, study, and innovation are needed for the sustainability transition to occur. All are important but their relationships to each other and to the whole are currently lost in the debate about the parts.

The Transition Projects

Project 1 - Past Trends

It is important work to understand what we have been doing, and how we got to this point. Governments usually have whole buildings full of people collecting and publishing historical data and statistics. Energy use, GDP, agricultural production, manufacturing, imports and exports are just a few examples. Researchers in all fields as well as businesses use this data to understand past trends, and very often predict future performance based on past trends.

Project 2 - Now

Where are we now? How much money do we earn? How much energy do we use and CO_2 do we produce? How much fuel do we import? How unsustainable are we? Again, governments spend a great deal of money keeping track of how we are doing, and it is important to know.

One of the most important aspects of the Now project is identification of problems, risks and issues.

Project 3 - Scenarios

Where are we going? What if we kept up with business as usual? What if we go back to the past? What if constraints and market forces drove evolution or revolution? How about that hydrogen economy? Green-techno-economic utopia vs brown economy and eco-suicide? How much carbon capture and storage would we need to maintain growth of fossil fuel use while "filling the wedge" in the curve to reduce CO_2 emissions? There are a lot of government workers, economists, businesses and a few researchers involved in developing scenarios about the future. Comparative scenarios are of course informative. Scenarios set the stage for discussion of change and let us explore responses to the problems, risks and issues that we face now. Scenarios and their simple forward projection graphs and two axis diagrams are used as ways to communicate issues to a general audience. However, scenarios are not plans or strategies. Scenarios are not risk assessment or risk analysis. It is important to explore scenarios, but to understand there is still a lot of work to be done beyond scenarios to actually identify and launch transition projects.

Project 4 - Vision for Feasible Sustainability

As stated above, our group may have been among the first to attempt this project. The vision project entails purposeful re-design of what we already have and what we already know, but with the un-sustainable aspects eliminated. The brainstorming work involved is focused on discovering what the people who know everything we know, are doing to meet their needs - but in a sustainable way. This is in contrast to scenarios (Project 3) which give projections about the future, but usually are lacking the hard-feasibility and virtual system design and modelling of the visioning project. Writers and movie makers often imagine future settings, but again, without real feasibility, these ideas about the future don't really provide vision.

Project 5 - Back Casting

This project involves identifying the core differences between the feasible sustainability vision and the current system. It also involves identifying the barriers to change, the opportunities and benefits to be realised for different change routes, and the new technologies, infrastructure and economic relations that might be developed. In the framework shown in Figure 1, the consideration of possible new technologies, infrastructure change and investment opportunities is placed after the exploration of the feasible sustainability vision. Currently, this project is often done after the identification of problems and issues in what we have called Project 2. The placement in this framework should provide better identification of opportunities and barriers.

Project 6 - Triggers
All change projects involve decision points, and/or triggers. For example a decision to change an institution's main computer operating system will include a decision point - a certain circumstance or time when the change programme will begin. In a society the triggers for change can be changing values, expressed by protests or public awareness campaigns. Other triggers may be disastrous failures of current systems. It is important to explore the possible triggers for change, and to plan for them. These triggers will initiate a drive to curtail un-sustainable consumption or emissions. The triggers are not effective if there have not already been viable solutions developed through research and innovation.

Project 7 - Transition
The changes that would lead in the direction of feasible sustainability will be made by businesses and communities, and will involve optimisation and change engineering. There is a great array of change projects, as nearly every facet of our current society has un-sustainable aspects. We propose that such a sweeping transition will probably happen in response to changing social values. This institutional shift could happen in much the same way that safety went from being something that was basically non-existent in the early part of the industrial age to something that is now expected by all sectors of society, planned for in design, regulated through standards, and communicated and actively managed at all levels. One of the main changes that will lead to a feasible sustainable future is a shared social attitude that un-sustainability is wrong and unacceptable. In the same way that safety is continuously monitored and failures used as triggers for change, attention to sustainability will be expected as part of good practice. People who do not measure and test their operations and products for sustainability will be considered negligent.

The Visioning Project

Regional Setting and Transport Energy System
The city of Christchurch has access to a sea port and is on the national rail line. Except for the residential areas on the hills, the city is flat, and covers an area of roughly 32 km^2. Recently, suburb developments have emerged on the outer edges of the city, and farms are being converted into low density, large size housing called “lifestyle blocks” at an alarming rate. The population of Christchurch is around 330,000. The land use can be described as medium to low density suburban areas with several concentrated industrial areas, and numerous American-style shopping malls and other retail areas. The vast majority of residents live in single family detached homes, though the trend has been to divide an existing 700-1000 m^2 lot into two or three with in-fill housing. Homes are usually surrounded by 2 meter high privacy fences, even when they are on very small size lots. Retirement villages which resemble condominium complexes are springing up as New Zealand’s aging population has investment capital due to soaring home prices over the past decade. The agriculturally productive Canterbury Plains border the city of Christchurch to the north and west. Grain, fruit, vegetables, sheep, chickens, pigs and beef cattle and dairy cows all do well in this environment. There are hills to the south, and the ocean to the east.

Electricity for the city is supplied primarily by hydropower from the glacially fed lakes in the Southern Alps to the south and west. When these projects were developed in the 1960's and 1970's, the electricity supply was very low cost and abundant. Thus, residential cooking, water heating, and space heating have relied on electricity. Currently, gas and coal generated power is needed from the North Island in the winter to provide for high peak demand. Nearly 40% of households currently rely on wood for some space heating and there is also some use of natural gas. Wood is plentiful but relatively expensive to have delivered. There is also a historical and on-going problem with winter air pollution from the use of wood fires. The natural gas supply is from the North Island, so gas is supplied in bottles and is relatively expensive. Insulation was not required in buildings until the mid 1970's. As a result, around 40% of homes are poorly insulated or have no insulation at all. The climate is cold and damp in the winter, with several months where overnight temperatures are below freezing.

In the 1950's the city had a very high rate of bicycle ridership and some of the city's electric trams were still in service. There were regional trains that brought agricultural produce into the city. Today there is a relatively effective bus system and some attention to providing bike lanes and bike parking facilities, but the majority of trips are carried out by personal vehicle. There has been one bus trial that used a biofuel additive and the bus was decorated accordingly. There are also several known characters who collect used fish and chip oil and use it to make diesel fuel for their vehicles. One of the state owned energy companies, Solid Energy, has invested in a scheme to produce biofuel from algae. At the present time, transport fuel is provided by imported petroleum and diesel, with a small number of liquefied natural gas and compressed natural gas vehicles.

The visioning project scope was set as the transportation sector only - we did not consider residential, commercial, or industrial energy consumption in this exercise. We chose the area of Christchurch called the Burnside High School Zone for our study because it fits some of the criteria for a community - chiefly that the people of this area educate their children together and live in proximity to each other. There is a high school, a middle school and two elementary schools in the zone. The population of the zone is in the range of 10,000 people. The infrastructure prior to transition included relatively wide streets in the traditional Kiwi style of quarter-acre lots with front and back sections. Pre-transition there was one library, several medical clinics, two shopping malls and several corner dairies with bakeries, take-away restaurants, butchers, post shops and book stores. There was one recreation centre and several large parks.

Feasibility and Modelling Method

The first step was to determine the energy available for transport, and to set the criteria for transport needs. A previous study of liquid biofuel potential for the Canterbury region (Judd 2002) gave an indication of the scale of that resource at about 5% of current fossil fuel use. The transitioned Silke Village has insulated homes and clean burning wood appliances for heat and hot water, freeing up some electricity capacity for transportation. A distribution of human mobility was assumed with 10% of people un-able to complete a 1.5km journey either by foot or bicycle. These 10% might be disabled, have care of infants, or be very old, and would require transport assistance. Further assumptions were based on demographics, with 85% of households having week-day trips to employment and 35% of households requiring access to an educational facility. Of all personal trips, 95% of destinations were in the village and 5% required hauling of goods. We assumed that the people would be able to locate in a residence that was within 2km of their most common destinations, e.g. work and school, or that they would be willing to ride their bike farther than that if they chose a house outside the 2km radius.

The second step was to set the rules for development of the Silke Village. The first rule was that the existing urban form would be the starting point for the development. The pre-existing infrastructure investments would be preserved to the greatest extent possible. The second rule was that the local natural ecosystem would be restored along rivers and streams, and the micro-climate, groundwater hydrology, and riparian ecosystem stabilized. The third rule was that productive areas within the village would be used in a coordinated way for food production to the greatest extent possible. The fourth rule was that all residents would have access to work and education destinations, plus 90% of all other destinations by human power and renewable motorised transport. This rule implies that a 2km radius around each house must include 90% of activity destinations.

A method was developed to accomplish the transformation development of Silke Village in order to ensure the urban form was human transport accessible. A scale model of the Burnside High School Zone was constructed as illustrated in Figure 2. Every home and facility, street and park and stream was depicted. A set of strings representing 0.5, 1.5, and 5 km were used to determine the travel radii from each home and each employment, market or service destination. The human power travel radius was used to determine how to place new market, production or service developments in the village. It was also used to make decisions about removal of existing single family homes and replacement with appartments and condominiums. The personal transport design rule is that 90% of the list of destinations and all of the essential services must be accessible within the 1.5 km radius from 75% of residential units. 10% of residences must be inside 0.5 km to essential services, and the remainder need to be within the 5km healthy bike ride radius.

A list of jobs was produced and maintained as the Silke Village was developed. The first list contained the pre-transition employment. A list of services was also produced and essentially of each service was assigned, for example essential services like medical emergency treatment and food, necessary services like banking and cafes, and optional services like recreation and retail. The nutritional requirements for humans was found from various sources, and a set of food requirements was established and translated into weight of each category of food per person per day. Categories of food include protein, starch, vegetable, and fruit.

Visitor's Tour of Silke Village – Vision Project Results

The first point of difference you will notice between Silke Village and pre-transition Christchurch is that there are no 2 meter privacy fences. Much more direct foot-path and bike-path access was needed through the village than could be provided in the setting which was honeycombed with privacy fences and walls. Removal of these walls also provided much more flexibility and optimisation of food production from the land. The second striking feature is that the paved streets are much smaller, with lanes marked for pedestrians and bicyclists. There is the occasional electric delivery vehicle or taxi, which takes over the bike lanes, but they move very

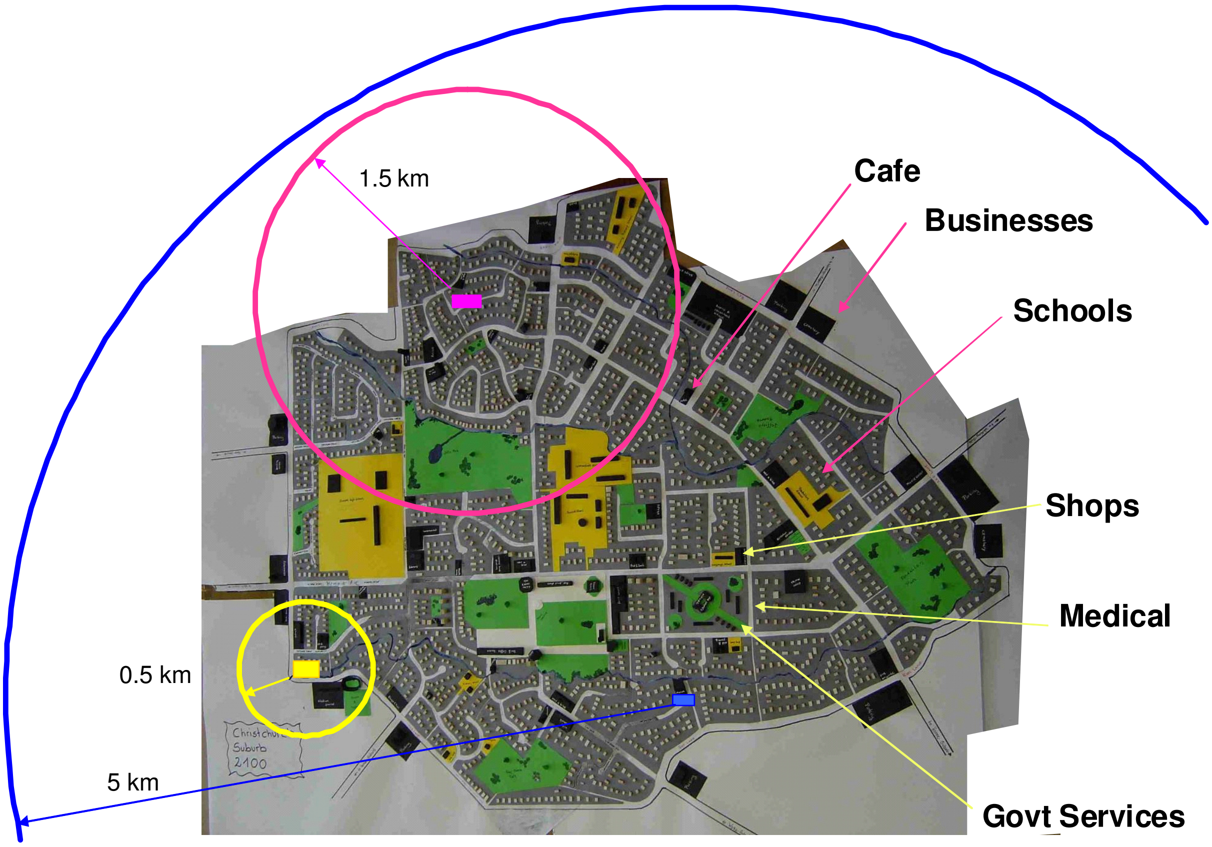

Figure 2. Plan view of the Burnside High School Zone with the 500m, 1.5km, and 5km travel radius around example houses.

slowly and have a flashing green light on top and a soft warning tone. There has not been a serious injury transport accident in Silke Village. It is safe, quiet, and the air is clean.

One of the new professions in Silke is that of environmental steward. These biology and ecology specialists are responsible for monitoring the native corridors including aquatic health, trees and plants, birds and insects, and the marine reserves. All of the streams have been regenerated, as have the hillsides, river catchment areas across the plains, and the shoreline. A zone 20 m on either side of a stream is excluded from man-made structures. The streams have natural shaped banks and stream beds, and native plants grow freely along the banks. The filtering of water run-off provided by these un-trampled zones has provided clean water and abundant stream life. Bird populations are very healthy as the stream corridors, plains reserves, and hillside bush are connected through nature corridors. The great benefit of this system, where 30% of the total land is in healthy native bush, is the stabilization of the local microclimate. This means much less irrigation is needed in the market gardens around the village as the ground-level humidity and soil moisture are stabilized. The village residents provide the salaries for the bush monitors from their property taxes.

About 10% of the pre-transition homes needed to be removed and replaced with higher density concominiums. These homes used to be where the new business center shown in the center of Figure 3, and the new civic and medical services center shown to the left, are now located. The high school and middle school grounds are behind these new centers in the figure. These centers represent the jobs and services that used to be commuting destinations outside of the village, in the range of 6-10 km to the city center. The condominiums are located at the perimeter of these new centers, thus providing the residents with good access to amenities and the new open space markets. The remainder of the homes that were replaced with high density buildings were spread around the village. They were moved to make room for new local produce and bakery groupings where access was needed, and for food processing and micromanufacturing facilities. Personal transport energy required to participate in normal activities is much reduced from the pre-transition urban form.

Raw materials and bulk goods are shipped into Christchurch and distributed throughout the city via the renewable energy tram system. This means that local skilled labor to manufacture and process the goods for the local markets represent a large number of new jobs in the village. For example, wheat can be shipped from the plains into the city efficiently at the end of the harvest. The warehouse in the city processes the wheat into flour and distributes this in bulk to the local bakeries. Village residents walk or bike to their local bakeries to purchase bread. This system requies an order of magnitude less transport fuel than the pre-transition system with bread factories, truck deliveries to supermarkets, and car trips to supermarkets.

Another new profession is the Master Gardener. We estimate that about 20 gardeners work out of an office in the new town center. They are experts in horticulture. They use GPS-based software programs to plan, monitor, and optimize the food production in the low density urban area. They also work with a new profession of produce processors and marketers. The Silke Village residents pre-order their market produce through internet sites that helps them plan nutritious meals and purchase appropriate amounts of ingredients from those locally available. This optimisation means that the Master Gardeners plant food crops according to local demand and according to the best growing conditions and pest management. Where some of the desired produce would grow best in one of the villager's own garden, the Master Gardeners work with the home-owners. Garden workers tend the food production system, but home-owners can also choose to participate to earn a discount on their produce or a share of the harvest. The produce is brought to four weekly markets in different parts of the village and may also be delivered to homes. The optimization of this system also includes moving surplus harvest to processing centers for preservation. Another new profession is Master Preservers. These people, again with direct connection to customers, are experts in food preservation, including canning, pickling and drying. Charcoal fuel and biogas are delivered to these processing facilities to suplement the electricity needed for the processing. Food is stored in re-usable glass and ceramic containers which are returned to the processing facility after use in the home. A novel type of hand-cart and tricycle are the most common means for moving produce, processed foods and returning bottles short distances around the village. Electric delivery vehicles and lorries are available for larger loads.

Micro-manufacturing, optimizing of production, ecosystem management, and local creativity in food preparation and preserving have led to a new type of international economy. Ideas, recipes, problem solutions, and a wide range of other "soft goods" are traded electronically. This requires much less transport fuel than moving manufactured goods. Because local manufacturers have access to a high-technology tool kit, then can make things with a range of design. It is these ideas and designs that are traded, rather than the goods themselves. Sustained value in goods is much more highly prized than the number of items consumed or just a low price.

As you bike through Silke Village, you'll see that the micromanufacturing and processing facilities are located generally on the perimeter of the village along the Orbiter renewable tram line. This allows raw materials and energy supplies to be delivered directly by the electric train network. You will also notice that there are a good number of greenhouses growing fresh vegetables, and small fruit orchards. Every few blocks there is also a poultry operation that collects local food scraps and provides fertiliser for the gardeners. Fresh food and eggs can be delivered to local residences from these facilities and are also available from the daries (small local grocery stores) and the weekly open markets. These facilities often have a long narrow shape are are located on well-drained bitumen paved surfaces, which the Silke Village had plenty of. A good deal of the bitumen has been removed and replaced with gardens, trees, and waterways.

One of the pre-transition soccer fields is now a dairy farm, providing fresh milk to the village. Dairy farms and sheep farms on the plains provide cheese, potatoes and wool to the town via the regional renewable trains. In general, we calculated that 50-70% of food requirements would need to be produced in the urban area so that regional transport was not required. There is one orbital tram line that ran around the village as can be seen in the plan view in Figure 2. There is also one inter-village tram line that runs on the long straight avenue through the village. This line connects with markets on the plains, and with the central markets in the city center.

On the edge of the village there is a vehicle rental business. These are similar to the vehicle rental centers at various train stations around the country. The biofuel produced on the plains is distributed for use in large construction equipment, emergency vehicles, farm machines and the rental vehicles. People can use these rental vehicels to access the wilderness areas of the countryside for tramping and for research and education. The renewable trams and trains have been optimised for cost/benefit and thus carry mostly goods, not commuters (Krumdieck *et al.* 2004). Wind turbines in ideal locations are connected to local and regional transport grids. Goods movements are tracked and organized to move when the wind resource is available. This is a low-cost but high benefit system that supports local goods movements and inter-regional trade. It also allows movement of long-live, high value trade goods to the ports for overseas shipping by the country's fleet of sailing ships.

Waste removal is the final transport load considered. The pre-transition waste removal system uses more fuel than the total feasible bio-diesel production of the Canterbury plains to drive large trucks around the city and collect the city rubbish bags and used containers for recycling from each home once per week. This is transport energy which the Silke Village does not have. As with the other pre-transition transport services if it is not possible to provide the service, then the system is altered to a feasible position.

In Silke Village, the Master Gardeners would be appalled if anyone didn't return all kitchen wastes for composting. Compost collection sites are built into the landscape, and the gardeners make sure that the right water and mix of chicken manure is used to provide a valuable soil amendment. The condominiums and new business and civic center have composting toilets that add to this resource. Most temporary packaging is bio-degradable, and the permanent packaging is re-usable. The local manufacturers, including clothes, shoes, linens, furniture, appliances, vehicles… all design for local re-use and recycling. All items people use have a second life, which leads us to the final new profession in the village, the recycling managers. Wood, metal, fibers, glass and even the few plastics that people use can be used in another product if they have been designed with this in mind, and with coordination between the different manufacturers. At the very end of life, there is an incinerator, co-fired with wood pellets, that heats the civic center with its performing arts center and other facilities.

Figure 3. Scale model of the Burnside neighborhood of Christchurch with detail of the new town center complex.

Conclusion

We have proposed that looking at the whole problem is the best way to find holistic solutions to complex problems. A conceptual framework for the seven different projects of sustainable transition was presented. The importance of the vision of the future was discussed as a motivation for the renewable energy transport project. The project to create a feasible sustainability vision of a place where we currently live was ambitious, but necessary for understanding the whole low-fossil fuel transition. The concept design objectives were to create a place that we would want to live in where issues of un-sustainability do not pose risks to the residents. The group that pursued this project believed that human ingenuity and problem solving was up to the task of creating a good way of life using only sustainable renewable energy. Rather than assuming we must maintain fossil-fuelled expectations, we identified the un-sustainable aspects of the pre-transition Burnside suburb, and eliminated them from the Silke Village. The vision was then constructed through concept generation and feasibility design and modelling. Therefore, the vision of the Silke Village presented is simultaneously desirable, believable, and achievable.

References

Bossel, U., Eliasson, B., Taylor, G., 2003. The Future of the Hydrogen Economy: Bright or Bleak? Oberrohrdorf, Switzerland, 2003.

Diamond, J. M., 2005. *Collapse : how societies choose to fail or succeed,* Viking, New York.

Hammerschlag, Roel, and Patrick Mazza, 2005, Questioning Hydrogen, *Energy Policy* 33, 2039-2043.

Judd, Barry, 2002*, Fuels from Biomass – The Feasibility of Biofuels Production in New Zealand,* Energy Efficiency and Conservation Authority.

Keith, D.W., Farrell, A.E., 2003. Rethinking hydrogen cars, Science 301, 315-316.

Krumdieck, S., A. Hamm, A. Dantas and S. Minges, 2004. *"Performance-Objective Design for a Renewable Energy Transportation Circuit of Christchurch, New Zealand"* in Proceedings of the World Renewable Energy Congress VIII (Denver, Colorado, 29 Aug-3 Sept 2004).

Ministry of Economic Development, 2006, *Powering Our Future: Draft New Zealand Energy Strategy to 2050.*

Pimentel, David, and Tad Patzek, 2005, Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower*, Natural Resources Research* 14, 1 (March): 65-76.